FOCUSED KNOWLEDGE FOR THE BATTLEFIELD

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ABSTRACT

The United States Army is in the midst of a major transformation. The Future Force must be highly mobile, agile, and lethal to ensure its dominance in the future battlefield. This dominance is reliant on the ability to see and understand first (situational awareness). Persistent and pervasive sensing and processing, coupled with greatly increased speed of information flow, information assimilation, and decisive action, at and between all levels of our force, are necessary to fulfill this requirement.

The United States Army is most vulnerable in urban terrain. This highly constrained, complex environment presents a significant challenge to US forces, particularly dismounted infantry and military intelligence because opposing force activity is readily masked or obscured by background noise (commerce, schools, religious activity etc.). This paper proposes an intelligent interaction between the digitized dismounted units and military intelligence, for the significant benefit to both.

1. INTRODUCTION

The United States Army is most vulnerable in urban terrain. This highly constrained, complex environment presents a significant challenge to US forces, particularly dismounted infantry. In order to enhance situational awareness in the urban terrain, future dismounted squads will be augmented by networked mobile and static sensing assets; unattended ground sensors, small unmanned ground vehicles, a robotic Multifunction Utility/Logistics Equipment Vehicle (MULE), and small unmanned air vehicles. A future dismounted force engaged in urban warfare is depicted in Figure 1.

Each warfighter will act as a mobile sensor and communications node since they will be equipped with sensors such as GPS, imagers, laser rangefinders, and will be networked locally. This organic sensor and communications augmentation of dismounted squads is consistent with the Future Combat System (FCS) and Future Force Warrior concepts [1]. This concept has also been demonstrated by Army Research Laboratory in the Warrior's Edge program. This complex urban environment also poses challenges to Military intelligence [2] since opposing force activity is readily masked by buildings or obscured by background noise (commerce, schools, religious activity etc.). This sensor and communications network augmentation will provide a greatly increased level of information to the warfighter.

Figure 1. Future Urban Warfare Scene

In order to effectively utilize (lower uncertainty and enhance situational understanding) these streams of organic sensory data, it is necessary to fuse them before presentation to the warfighter. These fusion applications remove redundancies, correlate, aggregate, and integrate sensor information with context such as high resolution maps.

The communications and processing enhancements embedded in a small organic fusion station will also support effective linkages to other information nodes (local and global). This augmentation will enable the extension of the network centric warfare [3] to the dismounted infantry, effectively linking the future dismounted warfighter (along with organic sensors) to tactical networks and particularly to Global Military Intelligence (assuming security policy will allow). This network coupling of the dismounted warfighter (local world) and global Military Intelligence (global world) can significantly improve the situational understanding of both the dismounted infantry and Military Intelligence.

As an example, consider a dismounted force preparing to secure a portion of a town. Twenty (20) minutes prior to entering the town they receive a report that there are ten (10) communication channels that have become active in

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the last fifteen (15) minutes in the center of the town. They also receive a high resolution image indicating the recent relocation of vehicle obstacles in the town square. Lastly, they receive another report that a ten (10) vehicle convoy had stopped in the center of the town, fifteen (15) minutes ago.

The force is able to rapidly ingest this information and reactively plan and execute. Information generated by the local world can significantly affect the global world assessment of opposing force intent. This dismounted force entering the town can provide imagery of the building interiors and report on their structural integrity and fortifications. This force could be considered to be a probe, determining the opposing force strength in an area. Also, prior to a precision strike, organic sensors such as an imaging UAV could be emplaced to provide accurate battle damage assessment (BDA). The ground perspective image could be sent to the firing force to help determine if an additional strike is necessary.

2. ARCHITECTURE

It is important to recognize that with the introduction of a local fusion node, the battlefield fusion process would become somewhat symmetrical. This processing symmetry allows for efficient interaction between the local and global worlds. The increased local processing and subsequently increased available information also forces an increase in global processing.

Relevant global intelligence information can be invaluable to the dismounted warfighter provided it is significant and timely. It is also critical to not burden these warfighters with extraneous information or introduce more uncertainty. Therefore, this information must be filtered from the plethora of irrelevant (to this particular warfighter) information generated in the global world.

These filters must be intelligent [4] enough to select only information that meet a rigorous acceptance criteria based on time, space, mission, certainty, resolution, organization, etc. to minimize information overload or disbelief. Information that does pass these dynamic intelligent filters must be transformed to a representation that is readily fused and consistent with the available local information. Figure 2 presents a proposed architecture for this global and local interaction.

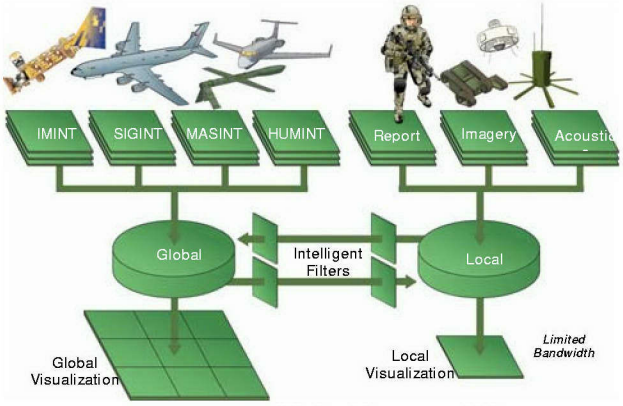

Figure 2. Local/Global Interaction

Similarly information from the local world must be filtered and transformed to be readily ingested and fused in the global space. This local information can impact the global world by providing high resolution ground perspectives, cue global assets, and detect local patterns which initiate global pattern analysis.

As an example, consider mortar attacks on a fixed installation. There may be cell phone activity just prior to firing and just after impact. The attacks may also be synchronized with the blue force patrol activity. This type of local pattern analysis and detection (utilizing both local and global information) would help military intelligence discern if these activities were repeated in a more global pattern.

3. LOCAL FUSION

Unlike the well established global fusion domain, the local fusion concept is just evolving. Local sensors included in the Warrior's Edge demonstrations included acoustic, magnetic, point infrared, visible and infrared imagers, laser rangefinders, ladars, and seismic. The global world can provide information from a myriad and diverse set of sensors {SIGINT, MASINT, IMINT, and HUMINT}. The global world also produces reports from a variety of analysts and other sources.

Envisioned local fusion node functionality includes the following:

1. Multiple Hypothesis Trackers
2. Video Mosaicing and differencing
3. Local/Global Fusion {SIGINT, MASINT, IMINT, and HUMINT}.
4. Cross Sensor Cueing
    - Between Organic Sensors
    - Between Local/Global Assets
5. Information Kiosk/Visualization
6. Planning/Control for Organic Sensors
7. Pattern Analysis
8. Training
    - After Action Review
    - Simulations

9. Communications Hub
    - Local Node
    - To Global Fusion Node
    - To other Local Nodes
10. Language Translation Triage (document)

Current processing power limitations (determined mainly by electrical power availability) restrict the use of a distributed fusion approach integrated within the warfighter's embedded processor (current PDA, wearable, or tablet technology). With the inexorable processing technology advances such as mainstream multi-core processors this restriction should be rapidly eliminated.

As an alternative approach, the Future Combat System concept envisions the squad/platoon level dismounted infantry augmented with a MULE as a logistics carrier to help unburden the infantry from their Herculean load. This vehicle should provide enough electrical power and space for a processing node. This functionality is extended here, by making the MULE an information carrier incorporating an information fusion station.

The communications and processing enhancements embedded in a local fusion station also enable linkage to other information nodes. This local fusion node is intended to provide a broad range of fusion functionality as well as other useful local information processing tasks.

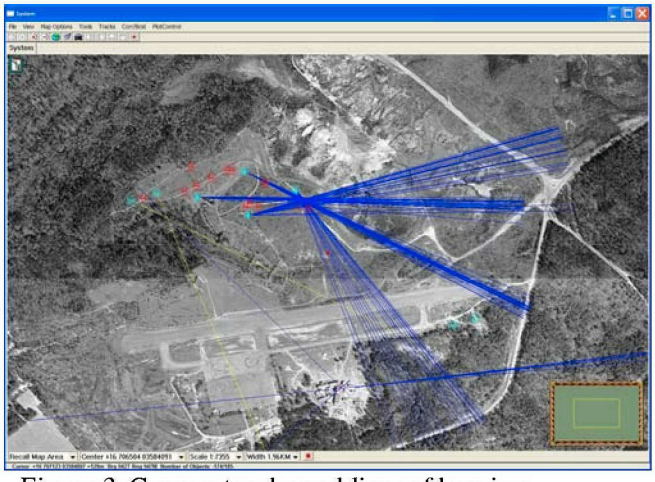

Figure 3. Convoy tracks and lines of bearing

Some examples of these processes will be given. The multi-hypothesis correlator/tracker (multi-target, multi-sensor) fuses the acoustic array based unattended ground sensor vectors to detect and tract convoys (Figure 3), as well as to localize gunshot and other transient acoustic events (Figure 4).

In both figures the sensors are represented by light blue dots. The red icons represent locations of the convoy. The blue lines depict the lines of bearing from the acoustic arrays. The acoustic and cued imaging sensors for the gunfire detection and localization were mounted on small robotic vehicles. Both the lines of bearing and either the visible or infrared video along those lines of bearing are sent to the MULE for fusion/localization. The yellow lines in Figure 3 represent the point infrared sensors used to detect and count convoy vehicles.

Figure 4 shows the line of bearing response to 5 sequential gunshots fired from the corner of a building at the McKenna MOUT site. These lines of bearing are fused to provide a position of the shooter. The cued visible and infrared sensors provide images from those lines to the warfighter.

Figure 4. Gunshot lines of bearing

An example of information from global sensors pertinent to the local squad world is high resolution imagery. During the demonstration a high resolution visible image chip was generated and received from the global world and was registered and integrated into the map display (ARCMAP) of the dismounted platoon leader. This image chip passed the spatial and temporal filters.

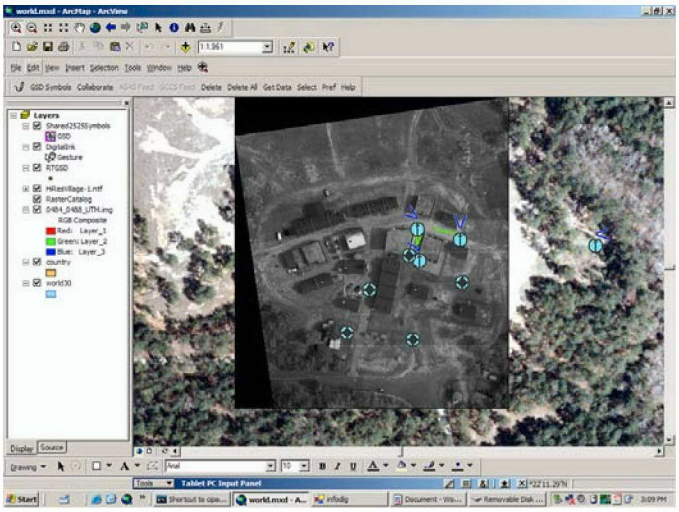

Figure 5. Platoon leaders display

This Local/global interaction illustrated the need for precise registration of global images of urban settings (if these images are to be used as part of the local operating picture). The fusion of the three robotic acoustic arrays yielded localization accuracy in the order of one or two meters. The distance between buildings at the demonstration site was 3-4 meters. Therefore local situational awareness requires a registration in the order of one meter. Figure 5 is an image of the platoon leader's display which has an image chip from a global sensor registered with ARCMAP.

This tablet display includes the location of the squad members and their robotic assets. The green lines are a use of "digital ink". The warfighters can graphically communicate and collaborate by drawing symbology and intensions (i.e., they can place standard military symbology on the display and draw freehand, to emphasize areas of interest, movement, or required action). This warfighter to warfighter graphical collaboration tool shows significant promise even in the rapid urban tempo.

4. LOCAL PROCESSING EXTENSIONS

The local fusion node has demonstrated tremendous potential to enhance the situational awareness of the dismounted infantry and military intelligence. Its potential can be further increased by the recognition that extensions to its core processes could also provide several other valuable functions to the dismounted infantry. Embedded training, pattern recognition, and asset control and management functions can be implemented by extensions to the local fusion design.

By archiving the blue and red force data and providing sophisticated playback options and analysis functions a fusion node could demonstrate the following embedded training functionality:

- Platoon After Action Reviews
- Battalion Review of TTP's
- Dismounted Infantry and Military Intelligence Cross Training
- Mission Rehearsals
- Military School Training Updates

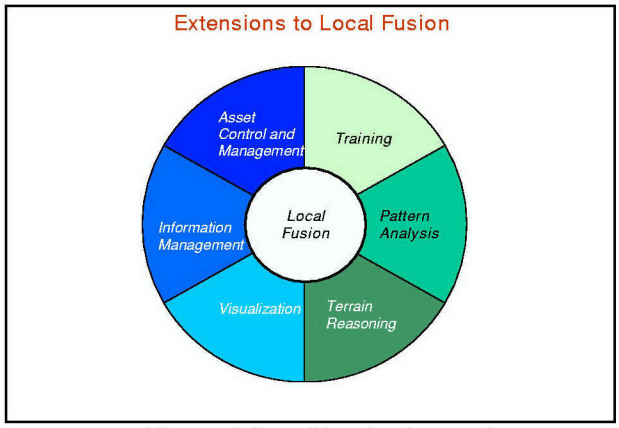

Figure 6. Local Fusion Extensions

Similarly, local datamining and pattern recognition functionality (listed below) can be implemented. This functionality is particularly useful in fixed site protection. Enhanced visualization [5] is key to the warfighters ability to rapidly recognize and assimilate any blue and red patterns. Figure 6 illustrates the functions that can be enhanced by being closely coupled to the local fusion process.

1. Playback with map context (window, forward and reverse)
2. Temporal and spatial correlation with other events
   - COMINT
   - HUMINT
3. Enemy activity (disruptions in power, communications, internet)
4. Background activity (prayer, business, school, etc.)
5. Blue Force activity (checkpoints, patrols, convoys, etc.)
6. Correlation with terrain features (lines of communications, masked areas, etc)
7. Histogram time of event, distance to event, time between events

A multi-resolution approach to visualization [4,5] as well as analysis is required. A global infrastructure with the ability to visualize the battlefield environment (terrain, weather, entities, features, communications, control measures, etc.) at various resolutions is needed in both the local and global worlds. This enables the commander to have a custom global view of the battlefield as well as a high-resolution local view to support critical decisions. This same infrastructure supports high fidelity local views for the dismounted commander as well as the ability to jump to other local views to support training or preparation for deployment. This scalability provides a single visualization approach suitable for both global and local applications. A 2D/3D approach is necessary since soldiers are very familiar with two-dimensional maps and can maintain their global

situation awareness. However the 2D representation is not as effective for high resolution, complex terrain. 3D representation is excellent for high resolution complex terrain, but it is very easy to lose a global perspective in all the detail presented. Presenting and coupling both views simultaneously eliminates many of the problems inherent in a single view approach. Figure 7 illustrates a coupled 2D/3D visualization approach.

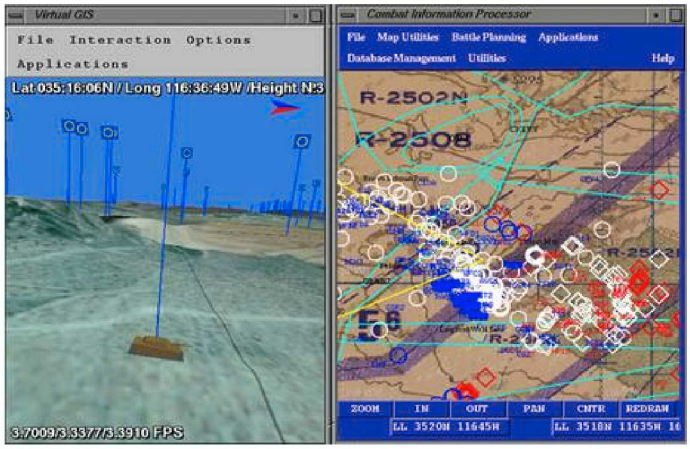

Figure 7. 2D/3D Linked Visualization

5. CONCLUSION

The Warrior's Edge program successfully demonstrated the functionality of a dismounted squad local fusion station. This local fusion station provided four critical functions:

- A coherent integration of the organic sensor information at the local level.
- The ingestion and fusion of global information that is significant to the squad.
- An effective real time visualization of the situation.
- The generation of ground perspective information for the global world.

The platoon leader and his RTO were able to quickly react to this fused sensor information and modify the action of the squad. As soon as mortars, gunfire, and convoys were detected and localized, the platoon leader was able to reactively plan and transmit this new plan graphically to his squad.

Situational awareness at both the squad and global levels can be significantly improved with an effective interaction between the local and global worlds. Although not demonstrated in this year's exercise, the ability to perform an after action review based on the fusion station's archived information would significantly improve the warfighter' ability to utilize both local and global information. This would be a step toward providing a training environment that links Intelligence and Dismounted Maneuver.

Although this effort is focused on the dismounted infantry, all these concepts apply to the mounted domain as well. This fusion station took several forms (depending on the platform) in the demonstrations to represent several classes of users. A robotic M-Gator represented a MULE type system. A HMMWV slide in fusion station was utilized for mounted and dismounted maneuver interaction. Work is continuing to shrink the power and size of this fusion station.

REFERENCES

1. Army Science and Technology Master Plan, 2003
2. Cordesman, Anthony H., "Intelligence Lessons of the Iraq War(s)" CSIS Publication, Aug 2004.
3. Alberts, David S., John J. Garstka, and Frederick P. Stein. " Network Centric Warfare: Developing and Leveraging Information Superiority". 2nd Edition Washington DC: CCRP Publication Series. 1999.
4. Emmerman, P., Movva, U. Intelligent Agent Battlespace Augmentation. Proceedings International Symposium on Methodologies for Intelligent Systems. Oct 2000.
5. Emmerman, P., Walrath J., and Winkler, R. (1998) " Making Complex, Multidimensional Battlefield Information Intuitive" Proceedings of the 21st Army Science Conference, USA.